THE GRAPTOLITE FAUNA OF GRIESTON QUARRY, NEAR INNERLEITHEN, PEEBLESSHIRE

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ABSTRACT. The graptolite fauna of the Upper Llandovery beds at Grieston Quarry, Peeblesshire, is described. It includes *Glyptograptus*? *nebula* sp. nov. (the youngest British diplograptid yet found) and *Monograptus drepanoformis* sp. nov. The relationship of the type *Monoclimacis griestoniensis* association to the *griestoniensis* Zone recorded elsewhere is discussed.

GRIESTON QUARRY (NT 3130 3618), 1 mile WSW. of Innerleithen, Peeblesshire, lies in an area of steeply dipping Upper Llandovery greywackes (Gala Group of Lapworth 1870) and has long been known for yielding relatively abundant graptolites indicative of a higher level in the Llandovery than any of the surrounding area. The quarry provided the type specimens of *Monoclimacis* [*Graptolites*] *griestoniensis* (Nicol 1850), and although this species is now an Upper Llandovery zone fossil (Wood 1906), there has been no review of the Grieston Quarry fauna since Nicol's original (1850) account.

Nicol first recorded graptolites from Grieston (1848, p. 204) but gave little information and no specific names. His main account (1850, pp. 53–5) was in fact quite detailed, including joint directions, but it did not include a map and in some cases it is difficult to relate exact horizons in the present quarry with his descriptions. He recorded three graptolite horizons but thought the highest of these might be a repetition due to faulting. The rest of his account consisted of a general discussion of the Silurian rocks of south-east Scotland and the structure of the whole Southern Uplands, ending with notes on the graptolites. His fauna included *Graptolites sedgwickii*, *G. distans*, *G. tenuis*, *G. convolutus*, *G. ludensis*, and the new species *G. griestoniensis*. The last three were described in some detail along with another form from nearby Thornilee Quarry. In conformity with the knowledge of the period, he correlated the Grieston Slates with the Llandeilo flags of Wales.

Lapworth (1870, p. 206) placed the 'Slates of Thornilee and the Grieston' at the top of his Gala Group, and recorded from Grieston Quarry, in addition to Nicol's fauna, *Diplograptus* sp., *Graptolites colonus*, and *Retiolites geinitzianus*. In his later detailed work, 'On Scottish Monograptidae', Lapworth (1876) recorded some of his monograptids from Grieston Quarry, including *Monograptus priodon*, *M. barrandei*, *M. exiguus*, *M. crispus*, and *M. convolutus* var. *proteus*. Remarkably, he did not accept *M. griestoniensis* as a valid species, but considered it (1876, p. 350) to be a peculiar view of *M. hisingeri* (Carruthers) (= *nudus* Lapworth). However, Elles and Wood (1911, pp. 413–14) accepted the species without question, and presumably with Lapworth's approval. Peach and Horne (1899, p. 206) gave few details of the quarry and gave as a fauna: *Monograptus priodon*, *M. convolutus*, *M. vomerinus*, *M. sedgwickii*, and *Retiolites geinitzianus*. Elles and Wood figured specimens of *M. priodon*, *M. acus*, *M. nudus*, *M. griestoniensis*, and *R. geinitzianus* from Grieston.

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The fauna described below is based mainly on Nicol's original collection from Grieston Quarry, which he donated to various institutions, together with collections made later by Nicholson, B. M. Wright, and Lapworth, as well as the authors.

LITHOLOGIES AND FAUNA OF GRIESTON QUARRY

The quarry exposes 43 m. (140 ft.) of flaggy greywackes which dip consistently north-west at between 60° and 65°. The detailed succession comprises alternations of greyish-green flaggy shales and fine- to medium-grained greyish-green and bluish-grey greywackes, with occasional nodular horizons. The greywackes, which are normally up to 0·9 m. (3 ft.) thick, but occasionally thicker, contain abundant small-scale sole markings, showing the strata to be the right way up. Some of the finer-grained greywackes, and all of the shales, split into uniform flags or 'slates', and these have been quarried in the past for roofing material.

The quarry is affected by a set of joints striking at 10°, and two joint planes in particular are conspicuous features on the quarry face. Both of these are mineralized and slickensided, and although Nicol thought one at least was a fault, there appears to have been little or no displacement along them. The more easterly of these cuts the lower part of the section and dips E. 10° S. at 80°. The second dips at 37° in the same direction and its face forms the present western limit of the quarry.

Nicol (1850, p. 54) recorded three fossiliferous horizons, two lower beds 3·1 m. (10 ft.) apart, and a third 21–24 m. (70–80 ft.) higher. As a fault intervened (in fact the more easterly of two major joints) he thought the third bed may have been a repetition of the first or second. The lowest bed '. . . a bed of slate . . . lately opened' contained the best-preserved graptolites, but the middle bed contained *Graptolites sedgwickii* in abundance. We have located the majority of Nicol's original collection, which comprises large slabs of bluish-grey greywacke containing well-preserved specimens, and likely to have come from the 'lowest bed of slate' which was being freshly worked at the time.

We have recently found this horizon 3·7 m. (12 ft.) above the base of the section, near the eastern corner of the quarry, and have collected large slabs of greywacke with well-preserved graptolites, and clearly the same material as in Nicol's collection. Another less-fossiliferous horizon occurs only 0·9 m. (3 ft.) above the base of the section, but we have been unable to find any other fossiliferous horizons in situ.

However, there are fragments in the quarry talus of fossiliferous micaceous greywacke, quite unlike the lithology of the main fossil horizon, but which matches closely collections made from Grieston by Nicholson, Wright, and Lapworth, not long after Nicol's original investigations. This lithology has not yet been found *in situ* on the quarry face. It may be from Nicol's middle or highest horizon, but we are referring to all this material as horizon 2, and the horizon of Nicol's original collection as horizon 1.

The fine-grained greywacke slabs of Nicol's collection, and samples collected by us from horizon 1, 3·7 m. (12 ft.) above the base of the section contain the following common species: *Monoclimacis griestoniensis* (Nicol), *Monograptus priodon* (Bronn), and *Monograptus spiralis* (Geinitz) sensu Elles and Wood, together with rarer examples of *M. discus* Törnquist, *Retiolites geinitzianus angustidens* Elles and Wood, *Pseudoplegmatograptus obesus* (Lapworth), and one example of *Diversograptus*? sp.

The micaceous greywackes of horizon 2 yield the following common species: *Monograptus drepanoformis* sp. nov., *M. priodon*, *M. spiralis*, *Pristiograptus nudus* (Lapworth), and *Glyptograptus*? *nebula* sp. nov., together with rarer examples of *Monoclimacis griestoniensis*, *Retiolites geinitzianus angustidens*, and *Pseudoplegmatograptus obesus*.

These two horizons show some notable differences in their fauna. In particular *Monoclimacis griestoniensis* is only common at horizon 1. *Monograptus discus* is restricted to horizon 1, whereas *M. drepanoformis*, *Pristiograptus nudus*, and *Glyptograptus*? *nebula* are common at, but restricted to, horizon 2.

THE AGE OF THE GRIESTON QUARRY BEDS

The fauna listed above represents an horizon in the *griestoniensis* Zone (Upper Llandovery) as defined at Trannon (Wood 1906, pp. 657–60), and as well as the zone species the following are common to both localities: *Pristiograptus nudus*, *Monograptus discus*, *M. spiralis*, and *M. priodon*. It is worth noting that the Trannon area itself has not been reviewed since 1906. The highest fossiliferous band of the *griestoniensis* Zone at Trannon yields *Monoclimacis vomerinus crenulata*, the zone species of the overlying *crenulata* Zone. This species is absent at Grieston, and so is *Monograptus marri*, a species common to all but the highest horizon of the *griestoniensis* Zone at Trannon. It seems likely that the exact horizon of the Grieston Quarry beds may be immediately below the highest fossiliferous beds of the *griestoniensis* Zone at Trannon (Wood 1906, p. 658).

The terms 'Grieston Slates' and 'Grieston Shales' have been applied to the beds of Grieston Quarry, the former term by Nicol (1850) and Lapworth (1870), and the latter by the Geological Survey (Peach and Horne 1899). Both Nicol and Lapworth considered that the term Grieston Slates could be applied to strata outcropping along the strike north-east and south-west of Grieston Quarry. Until a detailed investigation into the whole of the Gala Group is carried out in this area it seems unlikely that any term applied to the beds exposed in the quarry can be safely applied outside its confines. Thus we feel it is best to refer to the beds in the quarry as a horizon within the Gala Group (probably near the top). Lapworth himself expressed some doubt as to whether his divisions within the Gala Group had anything more than local geographical significance (1870, pp. 206–7).

Although the exact relationships of the beds of Grieston Quarry to those of the surrounding area are not yet certain there is no doubt that they contain the youngest (yet proven) graptolite fauna of the area. All the other graptolite localities of the Gala Group to the east and south-east, around Galashiels (Lapworth 1870, pp. 204–9, 279–84; Peach and Horne 1899, pp. 201–6) yield graptolites indicative of the underlying *crispus* and *turriculatus* Zones.

The specimen of *M. vomerinus crenulata* figured by Elles and Wood (1910, pl. 41, fig. 4*d*) from Williamshope, in fact comes from Meigle Quarry, but is a poorly preserved specimen of *M. galaensis* (Lapworth).

Lapworth (1870, p. 280) did not consider that the greywackes to the north of the Grieston slates belonged to the Gala Group as they were not found in the Gala district, and he stated: '. . . the Gala Group may provisionally be considered as terminated by the Thornilee Slates which appear to form the centre of a synclinal'. Thus although he

grouped 'The Slates of Thornilee and the Grieston' together (1870, p. 206) at the top of the Gala Group he must have considered the Thornilee Slates to overlie those of 'the Grieston'.

Between Grieston Quarry and the Ordovician–Silurian boundary 6 miles to the north-west occurs a barren greywacke sequence which presumably must represent the whole of the Llandovery below the *griestoniensis* Zone, so that a major synclinal axis somewhere near to Grieston Quarry seems quite likely, and all the beds north of this axis must young consistently to the south-east.

The whole of this area has a dominant Caledonoid strike (NE.–SW.) and another of the structural problems posed by the area is that at Douglas Burn (Peach and Horne 1899, pp. 141–2), only 6 miles south-west of Grieston Quarry, and on exactly the same strike, occur black graptolitic shales with Ordovician graptolites indicative of the basal Caradoc zone of *Nemagraptus gracilis*. Thus any synclinal axis through Grieston Quarry must rapidly plunge to the north-east.

SYSTEMATIC DESCRIPTIONS

Specimens from various institutions are prefixed as follows: Q, Palaeontology Department, British Museum (Natural History); SM A, Sedgwick Museum, Cambridge; GSM, Geological Survey Museum; GSM Geol. Soc. Coll., Geological Society of London Collection, now in the Geological Survey Museum.

Monoclimacis griestoniensis (Nicol)

Plate 103, figs. 1–5; text-figs. 1*a–h*

1850 *Graptolites griestoniensis* Nicol, p. 63, fig. 2.
1911 *Monograptus griestoniensis* (Nicol); Elles and Wood, pp. 413–14, text-figs. 279*a–f*, pl. 41, figs. 5*a–d*.
1940 *Monoclimacis griestoniensis griestoniensis* (Nicol); Přibyl, p. 10, pl. 3, figs. 1–3.
1945 *Monoclimacis griestoniensis* (Nicol); Waterlot, p. 77, pl. 32, fig. 333.
1952 *Monoclimacis griestoniensis griestoniensis* (Nicol); Münch, pl. 39, figs. 1*a*, *b*.

Lectotype. GSM 11,800 (Pl. 103, fig. 3; text-fig. 1*a*), ?Nicol's type slab, horizon 1, Grieston Quarry, Innerleithen. Figured Elles and Wood 1911, pl. 41, fig. 5*a*.

Discussion of lectotype. It is not clear from Nicol's original two figures whether they are different magnifications of the same specimen, or two different specimens. He may thus have illustrated a holotype or two syntypes, but in any case no specimen in his original collection can be matched exactly with his original figures. Elles and Wood (1911) stated that GSM 11,800 was Nicol's type slab but there seems to be no evidence for this, and in fact Nicol presented his original material, in the form of

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EXPLANATION OF PLATE 103

Figs. 1–5. *Monoclimacis griestoniensis* (Nicol), horizon 1, Grieston Quarry, Nicol Collection. 1, 2, GSM Geol. Soc. Coll. 6957, ? Nicol's original specimen, figured 1850, p. 63, figs. 2*a*, *b*; 1 ×3; 2, (enlargement of part of same) ×10. 3, Lectotype, GSM 11,800, figured Elles and Wood 1911, pl. 41, fig. 5*a*, ×3. 4, GSM Geol. Soc. Coll. 6957, ×3. 5, SM A21678, figured Elles and Wood 1911, pl. 41, fig. 5*c*, proximal end showing sicula, ×10.

Fig. 6. *Diversograptus*? sp., horizon 1, Grieston Quarry, Nicol Collection, GSM Geol. Soc. Coll. 6957, ×6. Also seen on fig. 4.

Figs. 7, 8. *Pristiograptus nudus* (Lapworth), horizon 2, Grieston Quarry, Wright Collection. 7, Q3078*c*, ×9. 8, Q3081*c*, ×10.

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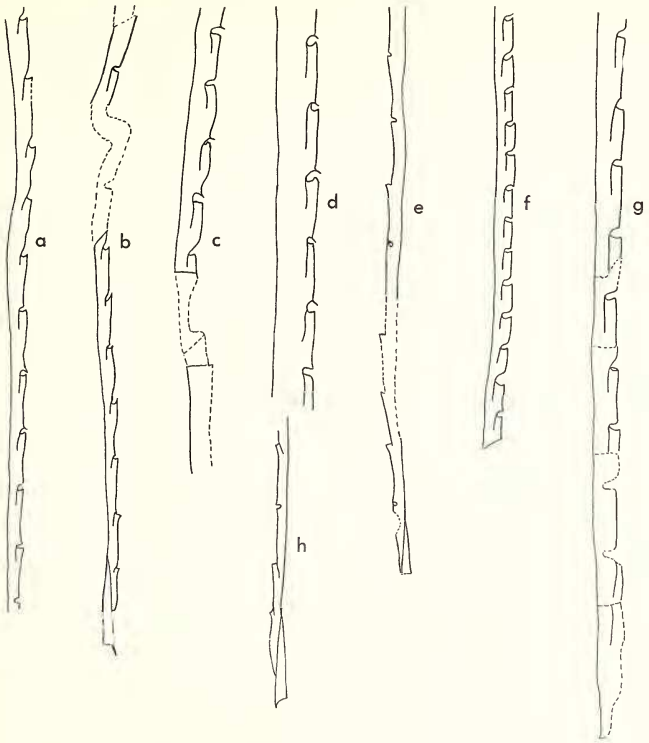

TEXT-FIG. 1. *Monoclimacis griestoniensis* (Nicol), horizon 1, Grieston Quarry, Innerleithen, Peeblesshire. All original Nicol Collection. *f* × 5, remainder × 12. *a*, lectotype GSM 11,800, proximal portion, figured Elles and Wood 1911, pl. 41, fig. 5*a*; *b*, *c*, *d*, SM A21678, figured Elles and Wood 1911, pl. 41, fig. 5*c*; *e*, SM A21681, figured Elles and Wood 1911, p. 413, text-fig. 279*b*; *f*, GSM Geol. Soc. Coll. 6957, possibly Nicol's original specimen (1850, p. 63, fig. 2); *g*, SM A21680, figured Elles and Wood 1911, pl. 41, fig. 5*d*; *h*, SM A21679.

greywacke slabs, to various institutions, including the Geological Society of London. The specimens presented to the latter are now in the Geological Survey Collections, and one of these, GSM Geol. Soc. Coll. 6957, according to their catalogues, contains the type specimen. Indeed one specimen on this slab (Pl. 103, figs. 1, 2; text-fig. 1*f*) compares favourably with Nicol's original drawing, but it is impossible to be certain. In any case Přibyl (1948) selected GSM 11,800, Elles and Wood, 1911, pl. 41, fig. 5*a* as lectotype. This is unfortunate as this specimen is a distal fragment, and better and more complete specimens are available from Nicol's type collection.

Material. Numerous specimens on greywacke slabs from Grieston Quarry (horizon 1) presented by Professor James Nicol to the Geological Society of London, Sedgwick Museum, Geological Survey of Great Britain, and British Museum (Natural History). Rare specimens from horizon 2, Grieston Quarry, B. M. Wright and H. A. Nicholson Collections, British Museum (Natural History).

Diagnosis. Long, slender, straight or slightly arcuate monograptid, up to 0·8 mm. wide, thecae 10–8 in 10 mm. of typical *Monoclimacis* type; proximal thecae showing little curvature and having everted apertures; distal thecae of typical climacograptid shape.

Description. The rhabdosome is long and slender, either straight or showing slight but continuous ventral curvature. The longest fragment is 90 mm. long, but the greatest width is only 0·8 mm. In the most complete specimen (Pl. 103, fig. 5; text-figs. 1*b–d*) the width increases from 0·2 mm. at the first theca to a maximum of 0·7 mm. at th 50, after 75 mm. The sicula is 1·4 mm. long and reaches just past the aperture of the first theca. The thecae number 10–8 in 10 mm., and gradually increase in length from 0·7 to 1·8 mm. after 75 mm. They overlap only $\frac{1}{6}$ at the proximal end but this value increases distally to $\frac{1}{2}$. The proximal thecae are almost straight with only a very slight geniculum, and the apertures are slightly everted. The geniculum becomes distally more pronounced, until the angle between the supra- and infra-genicular walls is 90°, and then the typical *Monoclimacis* appearance is reached. When well preserved the geniculum is produced into a flange which gives the aperture a hooded appearance (text-fig. 1*d*).

Occasionally the rhabdosome is preserved in dorsal or ventral view, and then it has the appearance of a series of vertebrae (Elles and Wood 1911, p. 413, text-fig. 279*f*). This is due to the expansion of the thecae at the aperture, associated with the overlying genicular flange of the next theca.

Remarks. This well-defined species is presumably the ancestor of the main Wenlock vomerinid stock, since it is earlier than *M. crenulata* at Trannon, and other Llandovery forms such as *M. galaensis* can only doubtfully be regarded as monoclimacids (Rickards 1968). This new description agrees with that of Elles and Wood, except that the length of sicula given here, 1·4 mm., is more than twice the 0·6 mm. given by them. One of us (P. T.) has examined specimens of *M. griestoniensis* collected by Wood from Trannon and figured by Elles and Wood (1911, p. 413, figs. *a*, *d–f*). These agree in dimensions with those from Grieston Quarry.

Occurrence and associates. At Grieston Quarry *Monoclimacis griestoniensis* is common on Nicol's original greywacke slabs which presumably come from horizon 1. It is associated commonly with *Monograptus priodon*, *M. spiralis*, and *M. discus*. It only occurs rarely at horizon 2 associated with *Pristiograptus nudus*, *M. drepanoformis* sp. nov. and *Glyptograptus*? *nebula* sp. nov.

EXPLANATION OF PLATE 104

Figs. 1–4. *Monograptus drepanoformis* sp. nov., horizon 2, Grieston Quarry. Fig. 2 Nicholson Collection, remainder Wright Collection. 1, Holotype, Q3072*b*, ×16. 2, Q3089*a*, ×10. 3, Q3073*b*, ×14. 4, Q3081*a*, ×12.

Figs. 5–9. *Monograptus spiralis* (Geinitz) sensu Elles and Wood. Fig. 5, horizon 1; remainder, horizon 2, Grieston Quarry. 5, GSM 11,801, Nicol Collection, ×10. 6, Q3080*a*, ×8, Nicholson Collection. 7, Q3081*b*, ×10, Wright Collection. 8, Q3080*b*, ×8, Nicholson Collection. 9, Q3074*d*, ×6, Wright Collection.

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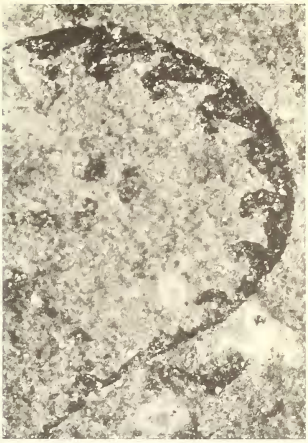

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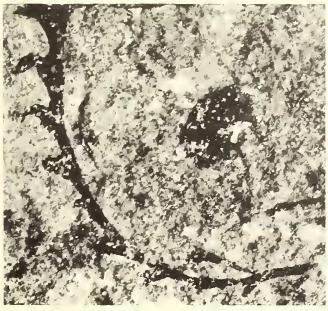

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The type locality is the only well-documented occurrence in Scotland, but the species occurs commonly in the Cross Fell Inlier (Burgess, Rickards, and Strachan 1970). It is common in Wales where it was designated the index fossil for the Upper Llandovery (Tarannon) *griestoniensis* Zone by Wood (1906) in the Trannon area. It has recently been recorded from the Welsh Borderland associated with late Upper Llandovery (Telychian) shelly fossils (Cocks and Rickards 1969). It occurs elsewhere in Europe (Přibyl 1940, Münch 1952); North Africa (Waterlot 1945); and Australia (Thomas and Keble 1933), but has not been recorded from North America.

TEXT-FIG. 2. *Monograptus drepanoformis* sp. nov., horizon 2, Grieston Quarry, Innerleithen, Peeblesshire. All ×7 approx. B. M. Wright Collection except *b*, which is Nicholson Collection. *a*, holotype, Q3072*b*; *b*, Q3089*b*; *c*, Q3081*a*; *d*, Q3073*b*; *e*, Q3079; *f*, Q3081*b*.

Monograptus drepanoformis sp. nov.

Plate 104, figs. 1–4; text-figs. 2*a–f*

Holotype. BMNH Q3072*b* (Pl. 104, fig. 1, text-fig. 2*a*), Grieston Quarry, horizon 2, Innerleithen, Peeblesshire; B. M. Wright Collection.

Material. Numerous specimens from horizon 2, Grieston Quarry.

Derivation of name. Greek, sickle-shaped.

Diagnosis. Short rhabdosome, up to 1 mm. wide, with tight ventral curvature, but slightly recurved dorsally at the proximal end. Thecae with little overlap, 12–10 in 10 mm. with conspicuous open hooks, and a tendency to expand throughout their length giving a triangulate appearance.

Description. The rhabdosome is short, up to 10 mm. and shows conspicuous ventral curvature, although the extreme proximal end is recurved with slight dorsal curvature. The sicula is 1·2 mm. long and reaches as far as the apex of the first thecal hook. The width increases from 0·3 mm. at the widest part of the first theca to a maximum of 0·8–1·0 mm. reached after only 10 thecae. Ten to twelve thecae occur in 10 mm. and these are 1·0 mm. long, including the hooks, and the overlap is always slight. The first two or three thecae have a straight proximal portion which is of constant width passing into a conspicuous open hook at the aperture. The third, or fourth, and later thecae expand throughout their length and thus have a triangulate appearance, but again the apertural region is a conspicuous open hook with the aperture pointing directly backwards.